CHARACTERIZATION AND MODELING OF STATIC RECOVERY PROCESS OF BRASS (COPPER ZINC) ALLOY

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BORANG PENGESAHAN STATUS TESIS

JUDUL: CHARACTERIZATION AND MODELING OF STATIC RECOVERY PROCESS OF BRASS (COPPER ZINC) ALLOY

SESI PENGAJIAN: 2008/2009

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CHARACTERIZATION AND MODELING OF STATIC RECOVERY PROCESS OF BRASS (COPPER ZINC) ALLOY

MOHAMAD HAFIZUL HISYAM BIN YAHYA

A report submitted in partial fulfillment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering
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NOVEMBER 2008

SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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Date: 12 NOVEMBER 2008

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Position: LECTURER

Date: 12 NOVEMBER 2008

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurently submitted for award of other degree.

…………………………......

Name: MOHAMAD HAFIZUL HISYAM BIN YAHYA

ID Number: MA 06004

Date: 03 NOVEMBER 2008

To my beloved mother and knowledge of human kind

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ABSTRACT

Static recovery process is a process of restoration of material properties back to original state. This process only occurs just below recrystallization temperature. In static recovery condition the dislocation of material is annihilated so the internal stress of material could be released. To obtain fraction of recovery, brass will be pre strain in various amount of value before go through annealing process in various static recovery temperature. This experimental process starts with machining the specimens by using manual lathe machining. Then all the specimens will be annealed in recrystallization temperature which is 570˚C. Next process is pre strain in various pre strain performed by compression and tensile test machine. After that process, specimens will be annealed in recovery temperature which is below 290˚C. Then final pre strain will be performed to obtain yield strength of recovered material. Finally based on the experimental data Friedel's model is used to acquire activation energy. From the calculation some of the activation energy value could be acquire such as -30 kJ/mol, 516 kJ/mol, 276 kJ/mol and 349 kJ/mol. These values of activation energy are compared with value obtained by using same method that used by Martinez which is in range of 216-357 kJ/mol. From the comparison percent of difference can be acquire. Since this percent of difference could be acquired, the significant value can be obtained and this is how Friedel's model is validated.

ABSTRAK

Proses pemulihan statik merupaka satu proses pemulihan sifat bahan kembali kepada keadaan asal. Pemulihan statik hanya berlaku dibawah suhu penghabluran semula. Pada keadaan pemulihan statik, logam terherot akan dihapuskan supaya tegasan dalaman bahan tersebut dapat dilepaskan. Untuk mendapatkan darjah pemulihan, loyang akan di pra terikan dalam beberapa nilai sebelum disepuh lindap dalam beberapa nilai dalam suhu pemulihan statik. Proses ujikaji ini dimulakan memesin bahan ujikaji dengan menggunakan mesin larik secara manual. Kemudian semua bahan ujikaji akan disepuh lindap pada susu penghabluran semula iaitu pada suhu 570˚C. Proses seterusnya ialah pra terikkan dalam beberapa nilai dengan menggukan mesin mampatan dan mesin teikkan. Setelah proses tersebut dijalankan, bahab ujikaji akan disepuh lindap pada suhu pemulihan static iaitu dibawah suhu 290˚C. Pra terikkan terakhir akan dijalankan utuk mengetahui nilai kekuatan alah bahan yang telah pulih. Akhir sekali daripada data ujikaji permedelan Friedel digunakan untuk mendapatkan nilai tanaga pengaktifan. Daripada pengiraan nilai tenaga penaktifan dapat diperolehi antaranya ialah-30 kJ/mol, 516 kJ/mol, 276 kJ/mol and 349 kJ/mol. Niali-nilai ini akan dibandingkan dengan nilai yang diperolehi dengan menggunakan cara yang sama yang digunakan oleh Martinez iaitu dalam julat 216-357 kJ/mol. Daripada perbandingan tersebut peratusan pembezaan dapat diperolehi. Oleh kerana peratusan pembezaan dapat diperolehi, nilai yang berkaitan dapat diperolehi dan inilah cara pemoldelan Fridel dapat di buktikan.

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LIST OF SYMBOLS

ε	Strain
$\Delta\sigma$	Stress difference
σ_m	Yield stress of deformed material
σ_o	Yield stress of recover material
σ_r	Yield stress of undeformed material
X_{rec}	Fraction of recovery
Q	Activation energy
t	Time
R	Gas constant
T	Temperature
c_1	Constant
a	Constant
b	Constant

LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
Cu	Copper
Zn	Zinc
CNC	Computer Numerical Control

CHAPTER 1

INTRODUCTION

1.1 Project Background

Mechanical properties of metals can be changed by heat treatment process. This process typically done by combining varied types of mechanical deformation and annealing processes. Static recovery only occurs below recrystallization temperature and involves motion and extermination of point deflects as well as extermination and re arrangement of dislocation. It will result the formation of subgrain and subgrain boundaries. The unique feature of static recovery process is that it does not involve any change in grain structure of cold worked metal, the only changes is the dislocation disarrangement within existing grain. It is proposed that a series of heat treatment experiments are performed brass alloys in order to properly characterize the static recovery process. In this research tensile test will used to determine the difference of stress of static recovery between varies pre-strain specimens. Mathematical model will produced from the static recovery behavior. The mathematical will be useful tool to predict commercial end product mechanical properties.

1.2 Problem Statement

Static recovery is process of grain recovery below recrystallization temperature. Friedel’s model states that the degree of recovery depends on the amount of pre strain, time and temperature. It is important to validate this Friedel’s model so the manufacturer can easily predict end of the result after recovery process.

1.3 Objective

To validate Friedel’s model static recovery process for brass (cooper zinc) alloy

1.4 Project Scopes

This focus area is done based on the following aspect:

(i) Analyze stress difference using tensile and compression test.
(ii) Material used only Brass (copper zinc).
(iii) Pre strain at 2.5% - 12.5%.
(iv) Analyze static recovery.
(v) Specimens for tensile and compression test machine by manual machining.

CHAPTER 2

LITERATURE REVIEW

2.1 ANNEALING

Annealing is a process of heat treatment used to eliminate the effect of cold working. Annealing in low temperature condition may be used to remove residual stress during cold work process [3]. Annealing also know as stress relief by relieving internal strain from cold work, welding or some fabrication process [2]. Two common practice annealing process is full annealing process annealing. Full annealing involves heating the material to austenite region. For process annealing the material involve heating to a point just below the austenite transition temperature. Upon annealing several processes occur such as there is a large decrease in the number of point defects. There are also dislocations of opposite sign attract and exterminate each other. Then the dislocations rearrange themselves into lower energy configurations. Finally both point defects and dislocations are absorbed by grain boundaries migrating through the material. In this case, there is reduction will occur in the grain boundary area. Figure 2.1 show effect of annealing temperature on strength and ductility of Brass alloy. It's shown that most of the softening alloy occurs during the recrystallization stage. For brasses annealing temperature usually in range of 430-650°C and stress relief usually perform in 1 hour with temperature range of 204-260°C [2].

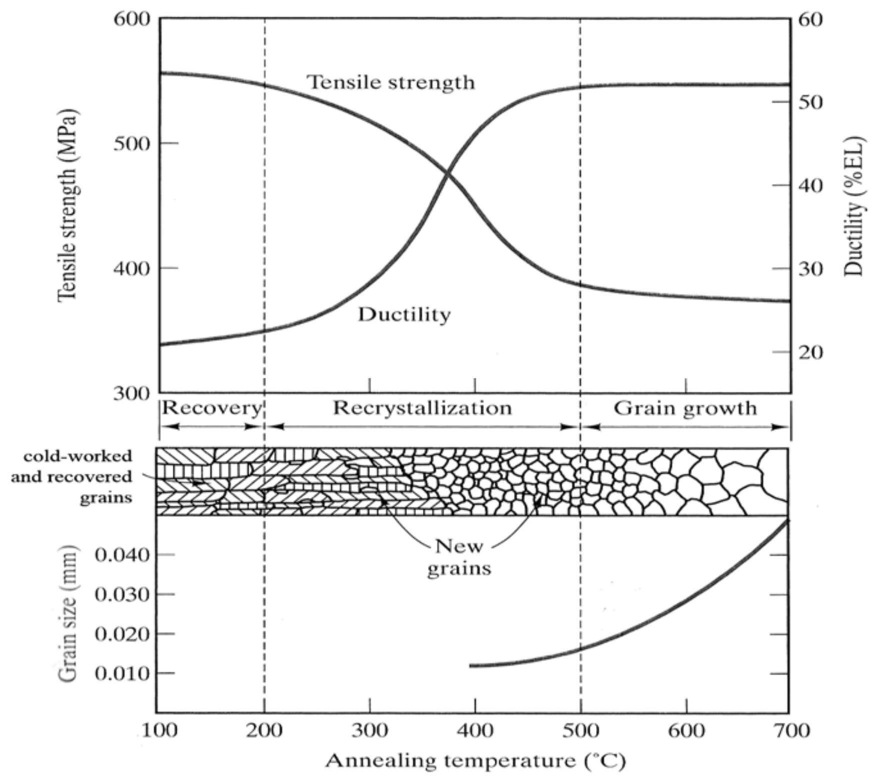

Figure 2.1 Schematic illustration of effect of annealing temperature on Brass [4].

2.2 COLD WORK

Cold work means mechanically deformation of a metal at low temperature [4]. The amount of cold work is defined by the relative of area changes at deformation area. Normally the amount of deformation defining by percent of cold work [3]:

$$\text{Percent cold work} = \left[\frac{A_o - A_f}{A_o}\right] \times 100 \tag{2.1}$$

Where A_o is the original cross-sectional area of the metal and A_f is the final cross-sectional area after deformation. When a metal having cold work, many of strain energy expended in the plastic deformation is stored in the metal. The strain energy can be form of dislocations and other form such as point of defect [1]. The density of dislocation can be express as the length of dislocation lines per unit volume (net units of m^{-2}). A heavily cold worked alloy can have a dislocation density as high as 10^{16} m^{-2} with a much higher hardness and stress [4]. When cold work increases, both yield and tensile strength increase. However, the ductility of the material will decrease and approach to zero. Example of cold work is rolling, forging, extrusion, wire drawing and stamping.

Figure 2.2 A cold worked Brass [4].

2.3 RECOVERY

Recovery is a process that some of physical properties of the materials are recovered. Recovery also states as the finest annealing process because there are no gross micro structural change occur [4]. If a material having a cold work, the microstructures of the material will contain lager number of dislocation. When heat is supply in recovery temperature which the range is just below recrystallization temperature range, internal stress in the material will relief allow the dislocation move from the boundaries of a polygonized subgrain structure as show in figure 2.3. this recovery process are called polygonization and its occur before recrystallization phase [1]. During this recovery process the mechanical properties of the material is not changing because the number of dislocation is not reduced. Recovery also knows as stress relief anneal. Recovery usually improves the corrosion resistance of the material.

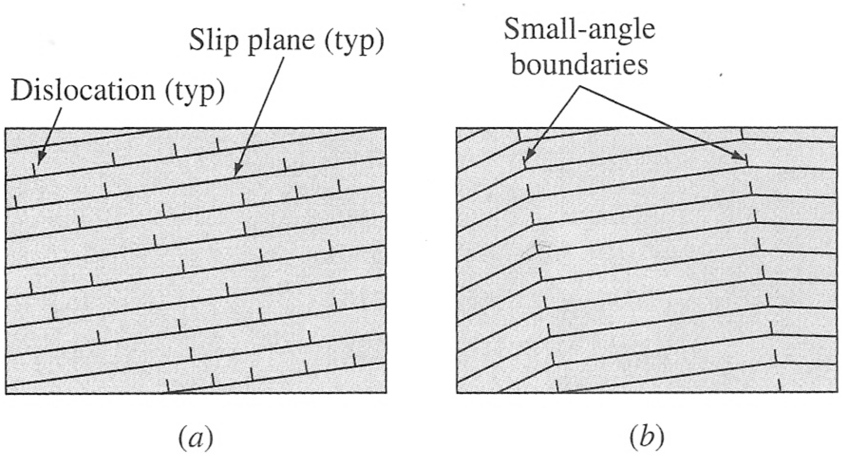

Figure 2.3 (a) Deform metal crystal showing dislocation. (b) After recovery heat treatment, dislocations move to small angle grain boundaries [1].

2.4 RECRYSTALLIZATION

Recrystallization is a process of formation of new grain by heat treating a cold worked material. Recrystallization occur when enough heat supply and new strain free grain are nucleated in the recovered metal structure and begin to grow and forming recrystallization structure. Recrystallization will rapidly recovery eliminates residual stress and polygonized dislocation structure. Because quantity of dislocation is greatly reduced, the recrystallization material has low strength but high in ductility [3].

Primary recrystallization occurs by two principal which is an isolated nucleus can expand with deformation grain or original high angle grain boundary can travel into more highly deform region of material. Recrystallization will occur if there is a minimum deformation of the material. If the degree of deformation is small (above minimum) the temperature for recrystallization occurs is higher. To decrease the time for recrystallization the temperature should be increase.

The degree of deformation will affect the final size of grain size. If there are more deformation, the lower annealing temperature for recrystallization and the smaller grain size. Grater amount of deformation needed to produce an equivalent recrystallization if the grain size is big. The purity of material will decrease the recrystallization temperature. Figure 2.4 show recrystallization process occurs in Brass in various times.

The figure 2.4 shown Brass grain after having cold work. Then new grain starts to appear after 3 seconds at temperature 580°C. The process continues after 4 seconds and many more grain appear. The complete recrystallization occurs after 8 second and substantial grain growth occur after 1 hour.

APPENDIX C

Data collected from Martinez journal

Temperature 300˚C			Temperature 400˚C		
1-Ry	Times (s)	ln t	1-Ry	Times (s)	ln t
0.95	3	1.098612	0.83	3	1.098612
0.92	6	1.791759	0.81	6	1.791759
0.9	10	2.302585	0.78	10	2.302585
0.88	50	3.912023	0.75	50	3.912023
0.85	120	4.787492	0.7	120	4.787492
0.83	900	6.802395	0.68	900	6.802395
0.8	2000	7.600902	0.64	2000	7.600902
0.79	4000	8.29405	0.63	4000	8.29405
0.78	6000	8.699515	0.6	8000	8.987197
0.77	8000	8.987197	0.59	10000	9.21034
0.76	10000	9.21034	0.59	14000	9.546813
0.75	25000	10.12663	0.6	25000	10.12663
0.74	50000	10.81978	0.55	50000	10.81978

Temperature 450˚C			Temperature 500˚C		
1-Ry	Times (s)	ln t	1-Ry	Times (s)	ln t
0.78	3	1.098612	0.67	3	1.098612
0.73	6	1.791759	0.64	6	1.791759
0.69	10	2.302585	0.63	10	2.302585
0.66	50	3.912023	0.57	50	3.912023
0.62	120	4.787492	0.53	120	4.787492
0.58	900	6.802395	0.5	900	6.802395
0.53	2000	7.600902	0.46	2000	7.600902
0.51	5000	8.517193	0.45	5000	8.517193
0.49	8000	8.987197	0.45	8000	8.987197
0.5	10000	9.21034	0.45	10000	9.21034
0.49	20000	9.903488	0.45	20000	9.903488
0.48	35000	10.4631			
0.47	50000	10.81978			
0.47	70000	11.15625			

Temp (˚C)	1-Ry=-a Ln t + b	a	b
300	y = -0.0207x + 0.9592	0.0207	0.9592
400	y = -0.0273x + 0.852	0.0273	0.852
450	y = -0.0296x + 0.777	0.0296	0.777
500	y = -0.0262x + 0.6817	0.0262	0.6817

APPENDIX D

Gantt chart final year project 1

PROJECT ACTIVITIES	W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W 14	W 15	W 16
Literature review	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Project briefing.		■														
Specimen drawing.			■													
Band saw and lathe demonstration.				■												
Request material.				■												
Specimens machining				■	■	■	■			■						
Tensile test.											■	■				
Annealing												■				
Proposal writing.													■	■		
Submit proposal.														■		
Presentation preparation.															■	■
FYP 1 presentation.																■

Gantt chart final year project 2

PROJECT ACTIVITIES	W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W 14	W 15	W 16
Report Writing	■	■	■	■	■	■	■	■	■	■	■	■	■			
Machining Specimens	■	■	■													
Annealing Heat Treatment				■	■											
Pre Strain					■											
Annealing in Recovery Temperature						■	■									
Tensile Test (find $\Delta\sigma$)								■	■							
Graph Plotting										■	■					
Friedel's Modeling												■	■			
Submit FYP 2 Report														■		
Presentation Preparation														■	■	
Final Presentation																■

APPENDIX E

Picture during final year project


Program Controller C5


S-300HB


B 150
307